REMARKS

STATUS OF THE SPECIFICATION

The Office objected to the disclosure because of informalities.

The Office objected to the equation $\mathbf{C} = \breve{\mathbf{C}}\mathbf{G}^{-1}$ as being inconsistent with the definition of the weighted concentration matrix $\breve{\mathbf{C}}$ given by $\breve{\mathbf{C}} = \mathbf{GC}$.

STATUS OF THE CLAIMS

Claims 1-3, 5-12, and 14-20 remain in the application. Claims 1, 2, 5, 6, 8, 9, 10, 11, 14, 15, 17, and 18 have been amended. Claims 4 and 13 have been canceled. New Claims 21 and 22 have been added.

The Office rejected Claims 1-20 under 35 U.S.C. 101 as being directed to non-statutory subject matter.

The Office rejected Claims 1, 6, 7, 9, 10, 15, 16, 18, 19, and 20 under 35 U.S.C. 103(a) as being unpatentable over the combination of *Andrew* and *Parker*.

The Office rejected Claims 2 and 11 under 35 U.S.C. 103(a) as being unpatentable over the combination of *Andrew/Parker* and *Keenan*.

The Office rejected Claims 3-5, 8, 12-14, and 17 under 35 U.S.C. 103(a) as being unpatentable over the combination of *Andrew/Parker* and *Vogt*.

SUMMARY OF THE INVENTION

The present invention is directed to a method for spatially compressing data sets enables the efficient analysis of very large multivariate images. The spatial compression algorithms use a wavelet transformation to map an image into a compressed image containing a smaller number of pixels that retain the original image's information content. Image analysis can then be performed on a compressed data matrix consisting of a reduced number of significant wavelet coefficients. Furthermore, a block algorithm can be used for performing common operations more efficiently. The spatial compression algorithms can be combined with spectral compression algorithms to provide further computational efficiencies.

SUMMARY OF THE ART

Andrew and *Hancewicz*, Appl. Spectroscopy 52(6), 797 (1998), discloses the application of two-way curve resolution methods, including principal factor multivariate curve resolution (PF-MCR) and orthogonal projection multivariate curve resolution (OP-MCR), to analyze three-way Raman image data. A 3-way array is reorganized into a two-way m x n data matrix D. PF-MCR uses a principal factor analysis (PFA) to decompose the data matrix D into submatrices C and S of abstract intensity and spectral factors, respectively. MCR is then performed on the abstract factors. A vector rotation can be applied to the abstract factors to emphasize the basic underlying structure of the data while keeping the vectors orthogonal. Alternating least squares (ALS) is then performed on the rotated abstract factors to produce optimized intensity and spectral profiles that reflect those of the real components in the data.

Parker et al., U.S. Pat. Pub. No. 2002/0146160, discloses method for generating a two-dimensional image from a three-dimensional hyperspectral data cube of a cervix in order to assign a tissue classification to the pixel data using pattern recognition. A one-dimensional wavelet transform is performed on each spectrum to separate the signal from the noise. The transformed data is then compressed using principal component analysis (PCA) via singular value decomposition (SVD) to remove the wavelet-conditioned noise background. This leaves global and local features of the spectral signal that are more easily recognizable by pattern recognition techniques. The resulting classification can be used to discriminate normal cervix tissue from diseased cervix tissue.

Keenan et al., Proc. SPIE 4816, 193 (2002), discloses algorithms for the constrained linear unmixing of hyperspectral images.

Vogt and *Tacke*, Chemometrics and Intelligent Laboratory Systems 59, 1 (2001), discloses algorithms for the PCA analysis of large data sets.

ARGUMENTS

SPECIFICATION

The Office objected to the disclosure because the meaning of "SD7276" in the Specification at page 2, line 6, and page 36, line 21, is unclear. Applicant has amended the Specification to add the U.S. Patent Application No. 10/772,548 that corresponds to the docket number SD7276.

The Office objected to the equation $\mathbf{C} = \breve{\mathbf{C}}\mathbf{G}^{-1}$ (page 15, line 23) as being inconsistent with the definition of the weighted concentration matrix $\breve{\mathbf{C}}$ (page 15, line 19), given by $\breve{\mathbf{C}} = \mathbf{GC}$. Applicant has amended the Specification to recite an unweighted concentration matrix given by $\mathbf{C} = \mathbf{G}^{-1}\breve{\mathbf{C}}$.

REJECTION OF CLAIMS 1-20 UNDER 35 U.S.C. § 101

The Office rejected claims 1-20 under 35 U.S.C. 101 as being directed to non-statutory subject matter. Specifically, the Office asserted that Claim 1 recites the mere manipulation of data or an abstract idea, or merely solves a mathematical problem without a limitation to a practical application. The Office further asserted that claim 10 merely manipulates data without ever producing a useful, concrete, and tangible result. The Office requested a written explanation of how and why the claimed invention produces a useful, concrete, and tangible result.

Applicant has amended Claims 1 and 10 to include the step of thresholding the wavelet coefficients of the transformed data matrix $\tilde{\mathbf{D}}$ or the transformed data factor matrix $\tilde{\mathbf{A}}$, respectively, that was previously recited in dependent Claims 4 and 13. Applicant has further amended dependent Claims 2, 5, 6, 8, 9, 11, 14, 15, 17, and 18 to be consistent with the amendments to Claims 1 and 10. This thresholding step compresses the data matrix to a smaller size and results in a spatially compressed concentration matrix $\tilde{\mathbf{C}}$. This spatial compression has the practical application of providing computation efficiencies in the analysis of large, high resolution full-spectrum images performed on a computer. *See* Application, page 4, line 24, through page 5, line 9. Such large data sets are routinely collected by full spectrum imaging instruments, including typical

commercial energy dispersive x-ray imaging systems and other spectroscopic imaging techniques. *See* Application, page 2, line 18, through page 3, line 5; page 10, line 25, through page 11, line 5; and page 47, line 29, through page 49, line 30.

Applicant submits that the computation efficiencies achieved by applying the compression method to full spectrum images produces a useful, tangible, and concrete result. According, Applicant submits that this rejection is overcome and that amended Claims 1 and 10 are in condition for allowance. Furthermore, Applicant submits that Claims 2-3 and 5-9, which depend from and further define Claim 1, and Claims 11-12 and 14-20, which depend from and further define Claim 10, are likewise in condition for allowance. *See* MPEP 2143.03.

CLAIMS 1, 6, 7, 9, 10, 15, 16 18, 19, AND 20, LIMITED TO PERFORMING AN IMAGE ANALYSIS ON A TRANSFORMED DATA MATRIX (OR DATA FACTOR MATRIX) TO OBTAIN A SPATIALLY COMPRESSED CONCENTRATION MATRIX, ARE NOT OBVIOUS UNDER 35 U.S.C. § 103(a) AS BEING UNPATENTABLE OVER THE COMBINATION OF *ANDREW* AND *PARKER*.

The Office rejected Claims 1, 6, 7, 9, 10, 15, 16, 18, 19, and 20, asserting that the Applicant's method of analyzing multivariate spectral images is made obvious by *Andrew's* curve resolution method in view of *Parker's* wavelet transform. To establish a *prima facie* case of obviousness, the prior art must teach or suggest all the claim limitations. *See* MPEP 2143. Applicant submits that neither *Andrew* nor *Parker* teach or suggest the limitation of performing an image analysis on a on a transformed data matrix (or data factor matrix) to obtain a spatially compressed concentration matrix.

Andrew only describes methods to factor a data matrix **D** into two submatrices, **C** and **S**, that represent concentrations and spectra. *See Andrew*, Equation 1, page 798. For example, factorization of **D** can be performed by PFA or OP-MCR, which yields abstract factors. *See Andrew*, Equation 4, page 799. ALS can then be performed on the abstract factors to produce optimized concentration and spectral profiles that reflect those of the real components in the data. *See Andrew*, Equations 9-14, page 800. These prior art techniques are described in the Application at page 11, line 21, through page 13, line 22. *Andrew* works with a full data set and does not teach methods to compress the data set. In

particular, *Andrew* does not teach transformation of the data matrix nor performing an image analysis on the transformed data matrix to obtain a spatially compressed concentration matrix.

Parker teaches spectral compression of a data matrix. That is, *Parker* works on a data set that is reduced in the spectral dimension. *Parker* applies a 1D wavelet transform to the pixel spectra of **D** and then compresses the extracted characteristics of each spectrum in order to classify each pixel according to the features of its compressed spectrum. *See Parker*, paragraph [0028]. Image processor 210 extracts features of the spectra that are useful for this pixel classification by the classifier 250. *See Parker*, paragraph [0036]. Therefore, *Parker* obtains a (untransformed) concentration matrix **C** and a transformed spectra shapes matrix $\tilde{\mathbf{S}}$. PCA/SVD is then performed on the transformed spectra to allow each spectrum to be described by a reduced (i.e., compressed) number of spectral dimensions at each pixel, rather than the full spectrum at each pixel. *See Parker*, paragraph [0037]. For example, assume an m-pixel x n-pixel x p-channel data matrix. A 1D wavelet transformation and compression of each spectrum provides a spectrum with a reduced number q channels, where $q < p$. Therefore, the spectrally compressed data matrix would be m x n x q. The spectral transformation/compression captures both global and local features of the spectral signal for ease of classification. *See Parker*, paragraph [0038]. A different spectral compression method is described in the Application at page 15, line 27, through page 36, line 16.

Conversely, Applicant teaches, and Claims 1-20 recite, methods for spatial compression of a data matrix. That is, Applicant works on a data set that is reduced in spatial dimensions. Applicant applies a wavelet transformation to **D** to obtain a transformed data matrix $\tilde{\mathbf{D}}$. *See* Application, page 39, line 6, through page 40, line 3. The transformed data matrix $\tilde{\mathbf{D}}$ can be compressed, for example, by throwing away the detail coefficients $\tilde{\mathbf{D}}_d$ of the original image. This compression provides a reduced number of spatial pixels, but with a full spectrum at each of the compressed pixels. For example, assume an m-pixel x n-pixel x p-channel data matrix. A one-level Haar wavelet transformation of the data matrix provides a transformed data matrix of n/4 approximation coefficients and

$3n/4$ detail coefficients. If the detail coefficients are thrown away, we are left with m x $n/4$ "super" pixels, but we still have a full p-channel spectral representation at each of the m x $n/4$ compressed super pixels. *See* Application, page 39, line 6, through page 40, line 13; and Figs. 10-11. ALS can then be performed on the compressed data matrix to provide a spatially compressed concentration matrix $\tilde{\mathbf{C}}_a$. *See* Application, page 40, line 25 through page 41, line 18; and Figs. 9-11. Spatial compression may have advantages for the analysis of multivariate spectral images, including higher compression and improved signal-to-noise. *See* Application, page 36, line 24, through page 37, line 5; and page 47, line 28, through page 49, line 30. In addition, spectral compression can be applied to each of the spatially compressed pixels to further compress the data matrix. *See* Application, page 43, lines 3-12.

Applicant submits that the Office has not established a *prima facie* case of obviousness. Accordingly, Applicant submits that this rejection is overcome and that Claims 1 and 10 are in condition for allowance. Furthermore, Applicant submits that Claims 6, 7, and 9, which depend from and further define Claim 1, and Claims 15, 16, 18, 19, and 20, which depend from and further define Claim 10, are likewise in condition for allowance. *See* MPEP 2143.03.

<u>CLAIMS 2 AND 11, LIMITED TO PERFORMING AN IMAGE ANALYSIS ON A TRANSFORMED DATA MATRIX TO OBTAIN A SPATIALLY COMPRESSED CONCENTRATION MATRIX, ARE NOT OBVIOUS UNDER 35 U.S.C. § 103(a) AS BEING UNPATENTABLE OVER THE COMBINATION OF *ANDREW* AND *PARKER* AND FURTHER IN VIEW OF *KEENAN*.</u>

The Office rejected Claims 2 and 11, asserting that the Applicant's method of analyzing multivariate spectral images is made obvious by *Andrew's* curve resolution method in view of *Parker's* wavelet transform and further in view of *Keenan's* division of a matrix into data blocks. To establish a *prima facie* case of obviousness, the prior art must teach or suggest all the claim limitations. *See* MPEP 2143. Applicant submits that neither *Andrew* nor *Parker* teach or suggest the limitation of performing an image analysis on a on a transformed data matrix (or data factor matrix) to obtain a spatially compressed

concentration matrix and that *Keenan* does not teach or suggest the division of a matrix into blocks.

The Office has asserted that "*Keenan* teaches constructing a data matrix **D** for submatrices $\mathbf{D}_{ij}$..." *See* Office Action, page 9. Applicant submits that this assertion is incorrect. *Keenan* defines D_{ij} as "the observed signal in the j^{th} spectral channel of the i^{th} pixel" of the data matrix D. *See Keenan*, page 194. Therefore, D_{ij} is a single number, not a data block D_i as claimed by Applicant. *Keenan's* Eq. (1) simply expresses the definition of the matrix multiplication of Eq. (2) element-wise in terms of elementary addition and multiplication operations. Further, Applicant has argued, *supra*, that Claims 1 and 10 are in condition for allowance. Accordingly, Applicant submits that Claim 2 and Claim 11 are in condition for allowance. *See* MPEP 2143.03.

<u>CLAIMS 3-5, 8, 12-14, AND 17, LIMITED TO PERFORMING AN IMAGE ANALYSIS ON A TRANSFORMED DATA MATRIX TO OBTAIN A SPATIALLY COMPRESSED CONCENTRATION MATRIX, ARE NOT OBVIOUS UNDER 35 U.S.C. § 103(a) AS BEING UNPATENTABLE OVER THE COMBINATION OF *ANDREW* AND *PARKER* AND FURTHER IN VIEW OF *VOGT*.</u>

The Office rejected Claims 3-5, 8, 12-14, and 17, asserting that the Applicant's method of analyzing multivariate spectral images is made obvious by *Andrew's* curve resolution method in view of *Parker's* wavelet transform and further in view of *Vogt's* Haar wavelet transform. To establish a *prima facie* case of obviousness, the prior art must teach or suggest all the claim limitations. *See* MPEP 2143. Applicant submits that neither *Andrew* nor *Parker* teach or suggest the limitation of performing an image analysis on a on a transformed data matrix (or data factor matrix) to obtain a spatially compressed concentration matrix and that *Vogt* does not teach or suggest the use of a Haar wavelet to transform and compress spatial features.

With regards to Claims 3 and 12 the Office asserts that "*Vogt* teaches using Haar wavelet transform for the purpose of analyzing spectral features" and that "it would have been obvious ...to use Haar wavelet as taught by *Vogt* for the purpose of analyzing and compressing spectral features..." *See* Office Action, page 10. As argued above, Applicant uses the Haar waveform to transform and compress <u>spatial</u> features, not

spectral features as taught by *Vogt*. Accordingly, Applicant submits that Claims 3 and 12 are in condition for allowance.

Further, Applicant has argued, *supra*, that Claims 1 and 10 are in condition for allowance. Accordingly, Applicant submits that Claims 3-5 and 8, which depend from and further define Claim 1, and Claims 12-14 and 17, which depend from and further define Claim 10, are likewise in condition for allowance. *See* MPEP 2143.03.

NEW CLAIMS 21-22

Applicant has added new Claims 21 and 22 that recite weighting of the data matrix **D** or data factor matrices **A** and **B**, respectively. Support for these new claims is found in the Application at page 14, line 9, through page 15, line 26; and page 16, line 5, through page 29, line 3.

CONCLUSION

Applicant has responded to each and every requirement and urges that the claims as presented are now in condition for allowance. Applicant requests expeditious processing to issuance.

Respectfully submitted,

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CERTIFICATION UNDER 37 CFR 1.8

I hereby certify that this correspondence and documents referred to herein were deposited with the United States Postal Service as first class mail addressed to: Commissioner for Patents, Alexandria, VA 22313-1450 on the date shown below.

Date: 8/27/07

By: Mary Loukota